NAVAL POSTGRADUATE SCHOOL
Monterey, California

EC 3210 FINAL EXAM 12/92 Po

- This exam is open book and notes.
- There are five problems; each is equally weighted.
- Partial credit will be given; be sure to do some work on each problem.
- Be sure to include units in your answers.
- Please circle or underline your answers.
- Show *ALL* work.
- Write only your name on this sheet.
- Exams and course grades will be available outside the Optical Electronics Laboratory (Bu 224) on Monday, 21 December (about noon).
- Have a good holiday season and enjoy your break!

Course grade: _____

| | | | |
|---|---|---|---|
| 1 | | 4 | |
| 2 | | 5 | |
| 3 | | | |
| Total | | | |

Name: _____

1. A hypothetical mode–locked laser produces a string of 50 ps wide pulses at a pulse repetition rate of 125 million pulses per second. The shape of the output pulses is triangular and the peak power is 1 kW. The output wavelength is 3 $\mu$m and the index of refraction of the material is 1.2.

   (a) Find the average power delivered by the laser.

   (b) If the material is Doppler–broadened, find the center value of the lineshape, $g(\nu_0)$.

---

2. A linearly polarized wave at $\lambda = 1$ $\mu$m is incident on a lithium niobate waveplate. The wave is polarized along the slow axis of the crystal. If the wave undergoes a phase shift of 10 million degrees while propagating through the crystal, find the thickness $D$ of the crystal.

---

3. A HeNe laser ($\lambda = 632.8$ nm) has a resonator mirror separation of 1 m. Each mirror has a radius of curvature of 1.20 m and a 95% reflectivity.

   (a) Find the spot size of the beam at a location that is 10 cm to the right of the right end of the laser.

   (b) Find the radius of curvature of the beam's phase at the same location.

---

4. A lasing material, having the energy diagram shown below, is placed into a resonator as shown. The material is Doppler broadened; the frequency linewidth is 2 GHz. The index of refraction of the material is 1.2. The internal loss coefficient of the material is 0.01 $\mathrm{m}^{-1}$.

   (a) Find the saturation irradiance.

   (b) Find the normalized threshold population inversion, $(N_2 - N_1)_{\mathrm{th}}/\mathrm{Vol}$.

---

5. A laser ($\lambda = 500$ nm) with an unsaturated gain coefficient of 0.08 $m^{-1}$ is used in the resonator below. The internal loss coefficient in the material is 0.01 $m^{-1}$. When the output mirror reflectivity is 90%, the output irradiance outside of the laser is 5 $mW \cdot cm^{-2}$.

   Find the output irradiance if the output mirror reflectivity is increased to 95%.